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## Methods of Recording Aphid (Homoptera: Aphididae) Populations on Potatoes and the Distribution of Species on the Plant[1]

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### Introduction

In Eastern Canada, aphids cause serious losses in the potato crop—directly by injuring heavily infested plants and indirectly as vectors of viruses. A field study of factors affecting populations of potato aphids necessitates a method of estimating populations that allows comparisons of results from different varieties of potato and from potatoes grown under different conditions. Davies (1934) described one of the first methods of estimating aphid populations in the field; he counted the aphids on lower leaves chosen at random, and expressed the population as aphids per 100 leaves. Simpson (1940) reported that the species of aphids on potatoes in Maine differed in their distribution on the plant; to obtain a better estimate of the population, he modified Davies' method and counted the aphids on equal numbers of leaves selected at random from the top, middle, and bottom portions of the plants. Other workers (Joyce, 1938; Hansen, 1941; Whitehead, 1943; Thomas and Jacob, 1943; Staniland, 1943; Jacob, 1944; Doncaster and Gregory, 1948; Münster, 1948) used various methods of selecting leaves for the sample but continued to express the population as aphids per 100 leaves. Much of the earlier work was in the form of surveys to determine the population of aphids above which the maintenance of healthy seed stock was not a practical proposition.

Heinze and Profft (1940), in Germany, counted the aphids on all the leaves of 20 to 30 plants chosen at random and expressed the population as aphids per plant. In Canada, Adams (1946) also made total-leaf counts; when the population exceeded 200 aphids per plant, she counted the aphids on 20 per cent of the leaves and estimated the number of aphids per plant. Moericke (1941) beat individual plants over a cloth and collected the aphids to examine and count in the laboratory. Thomas and Jacob (1943) also tried a beating method but claimed that not all the aphids were dislodged from the plant. In Australia, Bald, Norris, and Helson (1946) counted the aphids on equal numbers of top, middle, and bottom leaves; they estimated the areas of the leaves of the sample, and the total leaf area of the plants from which leaves were chosen; with these data they expressed the population as aphids per 48 leaves, per plant, and per unit leaf area. Broadbent (1948) estimated the population per plant by sampling equal numbers of top, middle, and bottom leaves and determined by count the average number of top, middle, and bottom leaves per plant. He also suggested a method of determining the population per plant (when the population level is low) by counting the number of top, middle, and bottom leaf units infested.

This paper deals with three methods of recording the populations of aphids on potatoes that have been used in studies in New Brunswick. A comparison is made between expressing the population as aphids per 100 leaves, aphids per plant, and aphids per unit leaf area.

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## Methods

The data used in this paper are from an experiment carried out at Woodstock, N.B., during the summer of 1949 to study the varietal effects of potatoes on the development of winged aphids. The varieties used were Katahdin, Irish Cobbler, Green Mountain, Houma, and Epicure. Five plots of each variety were planted in a latin square comprising a total area of approximately one acre. Each plot was 36 feet square and contained 12 rows of potatoes; the plots were separated from one another by 12 feet of fallow ground. The potatoes, planted by hand in machine-made drills on May 29, were cared for as if grown commercially, but no insecticides were used to control aphids. A copper fungicide to control blight, and calcium arsenate to control biting insects, were applied as sprays with a six-row Bean sprayer each week during July, August, and the first half of September.

Weekly aphid counts were made on each of the 25 plots throughout July and August and into September until the potatoes died as a result of late blight and severe aphid injury. The aphids were counted on a top, a middle, and a bottom leaf chosen from each of seven plants selected from the middle four rows of each plot; care was taken that choices both of plants and of leaves were at random. This made a total of 105 leaves sampled from each variety. The population per 100 leaves was estimated by taking twenty twenty-firsts of the population on 105 leaves. The area of each leaf of the sample was estimated by means of a series of photographic leaf standards (Thirmalachy, 1940; Bald, 1943). The number of aphids per unit leaf area was calculated from the formula $\Sigma x/\Sigma a$, where $a$ is the area of a leaf and $x$ the number of aphids counted on that leaf.

At the time of sampling each week, one plant was selected from an outside row of each plot and the numbers of top, middle, and bottom leaves were counted. Leaves were classified as top, middle, and bottom leaves by dividing the stalk into three approximately equal portions; the leaves of the younger axillary shoots were usually counted as top leaves unless their size approximated that of middle or bottom leaves; then they were placed in one of these two groups. The number of aphids per plant was estimated by means of the formula $\frac{1}{N}\{\bar{r}_1 \Sigma x_1 + \bar{r}_2 \Sigma x_2 + \bar{r}_3 \Sigma x_3\}$ .... (Anscombe, 1948), where $N$ is the number of plants from which a top, a middle, and a bottom leaf were selected; $x_1$, $x_2$, *and* $x_3$ are the numbers of aphids found on single top, middle, and bottom leaves *of a plant; and* $\bar{r}_1$, $\bar{r}_2$, *and* $\bar{r}_3$ are the estimates of the average number of top, middle, and bottom leaves per plant. The data obtained between July 21 and August 17 are used to compare methods of expressing aphid populations; for, during this time, plant size did not change appreciably and aphid injury to the plants was not severe. After the middle of August, the potatoes showed symptoms of severe aphid injury and suffered from an attack of late blight; many of the lower leaves were dead or dying and accurate counts were difficult to make. During this time parasites and predators of aphids were numerous, but counts made on 100-leaf samples showed that the aphid population remained high on each of the five varieties until the deaths of the plants.

## Results

In this experiment, aphids were first observed during the last week of June, when small numbers of *Myzus persicae* (Sulz.), *Macrosiphum solanifolii* (Ashm.), and *Aphis abbreviata* Patch were found on all five varieties; at that time *M. solanifolii* was the most abundant species, comprising over 90 per cent of the total population. Counts on July 5 and July 12 showed that *M. solanifolii* was still the most abundant species, comprising over 80 per cent of the total population, and that the population was less than 30 aphids per plant on all varieties. All five

## ERRATA

Correction, Vol. LXXXIV, p. 94, for lines 8-11, para. 3, read:—

$\frac{1}{N}\left\{ \bar{r}_1 \Sigma x_1 + \bar{r}_2 \Sigma x_2 + \bar{r}_3 \Sigma x_3 \right\}$ .... (Anscombe, 1948), where $N$ is the number of plants from which a top, a middle, and a bottom leaf were selected; $x_1$, $x_2$ and $x_3$ are the numbers of aphids found on single top, middle, and bottom leaves of a plant; and $\bar{r}_1$, $\bar{r}_2$, and $\bar{r}_3$ are the estimates of the average number of top, middle,

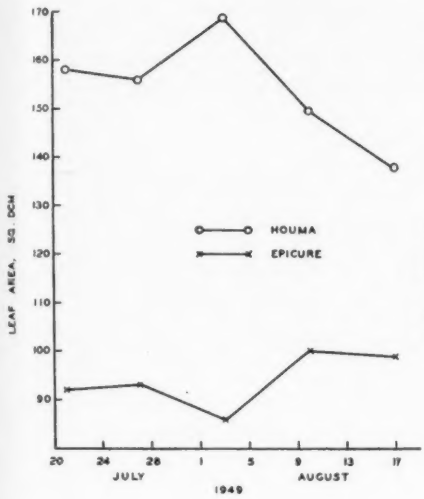


FIG. 1

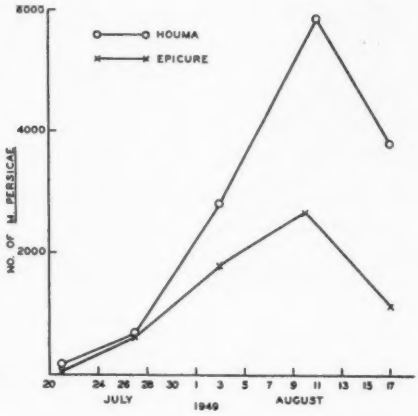


FIG. 2

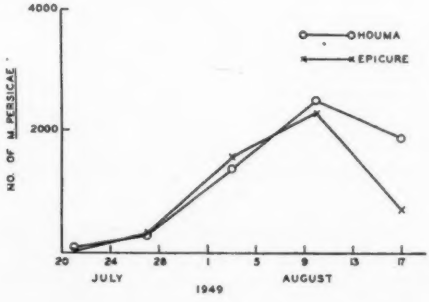


FIG. 3

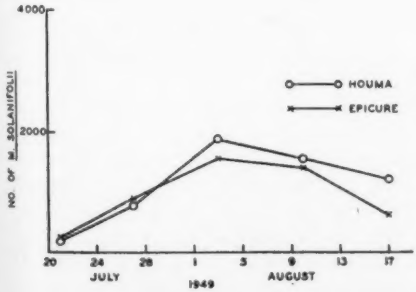


FIG. 4

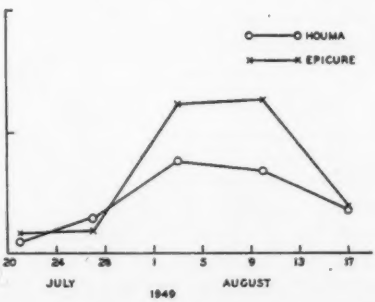


FIG. 5

varieties flowered in the early part of July, during which time aphids, particularly *M. solanifolii*, were numerous on the flowerheads. A count on July 21 showed that *M. solanifolii* and *M. persicae* were present in approximately equal numbers and the population was over 300 aphids per plant on each of the five varieties.

### Aphids per 100 leaves

Table I shows the average area of 33⅓ leaf samples from the top, middle, and bottom portions of the plants of each of five varieties for five weekly mid-season counts; the area of 33⅓ leaves was calculated from the area of a 35-leaf sample. There were no significant differences in the leaf areas sampled from the same plant positions on different days; but differences in the areas of the leaf samples from different varieties and from different portions of the plants were both significant at the one per cent level. There was also a significant interaction between days and varieties and between varieties and leaf positions.

TABLE 1.

MEAN AREAS OF 33⅓ LEAF SAMPLES FROM FIVE VARIETIES OF POTATO FOR FIVE WEEKLY MID-SEASON APHID COUNTS.

| Leaf Position | Variety | | | | |
|---|---|---|---|---|---|
| | Katahdin | Irish Cobbler | Green Mountain | Houma | Epicure |
| Top | 13.3* | 14.2 | 12.1 | 14.6 | 10.1 |
| Middle | 56.6 | 41.5 | 39.3 | 52.8 | 30.9 |
| Bottom | 46.2 | 36.8 | 37.7 | 68.4 | 30.2 |
| TOTAL | 116.1 | 92.5 | 89.1 | 135.8 | 71.2 |

*Leaf area in square decimeters, calculated from area of a 35-leaf sample.

Fig. I represents the leaf areas of weekly 100-leaf samples (equal numbers of top, middle, and bottom leaves) from Houma and Epicure; this shows that the area of a 100-leaf sample from Houma was consistently greater than that from Epicure, sometimes being twice as great. In another field experiment in which two of the treatments were early- and late-planted Katahdins, the areas of 100-leaf samples taken during July were over eight times as great from the early-planted as from the late-planted Katahdins. Such differences in varieties of potato, or potatoes of different ages, make comparisons of populations per 100 leaves inaccurate.

### Aphids per plant

The populations on Houma and Epicure for five weekly counts are given as aphids per 100 leaves in Fig. 2 and as aphids per plant in Fig. 3. The number of aphids per 100 leaves (Fig. 2)suggests that after July 27 the population on Houma exceeded that on Epicure; in fact, at the peaks of the populations, Houma appeared to support more than twice the population of Epicure. However, Fig. 3 shows that except for the count on August 17 the population per plant was approximately the same on the two varieties. The population of *M. solanifolii* per 100 leaves during the same period (Fig. 4) suggests that both varieties supported approximately equal numbers of *M. solanifolii*. However, on

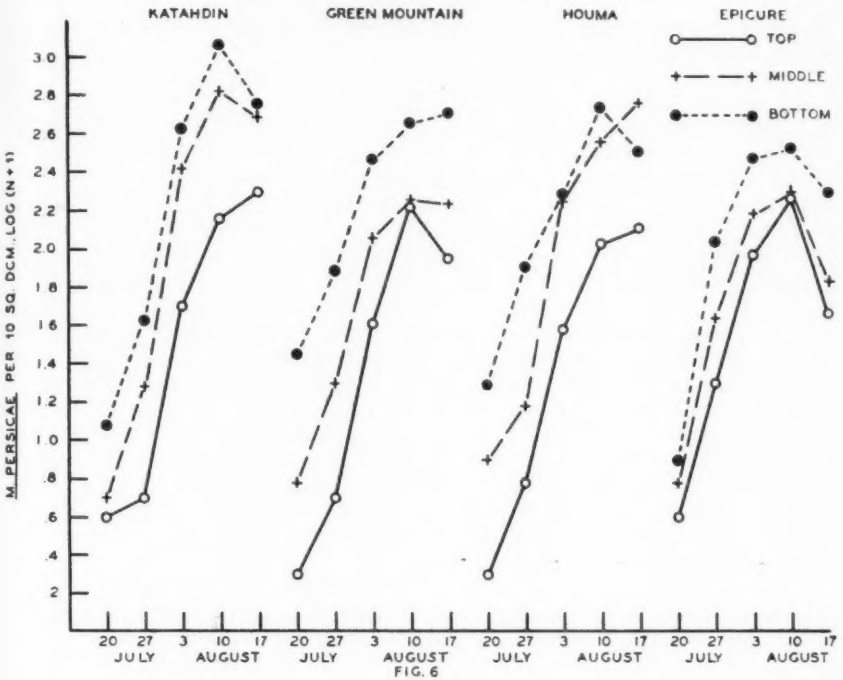
KATAHDIN
GREEN MOUNTAIN
HOUMA
EPICURE
TOP
MIDDLE
BOTTOM
M. PERSICAE PER 10 SQ. DCM., LOG (N+1)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
20 27 3 10 17
JULY
AUGUST

FIG. 6

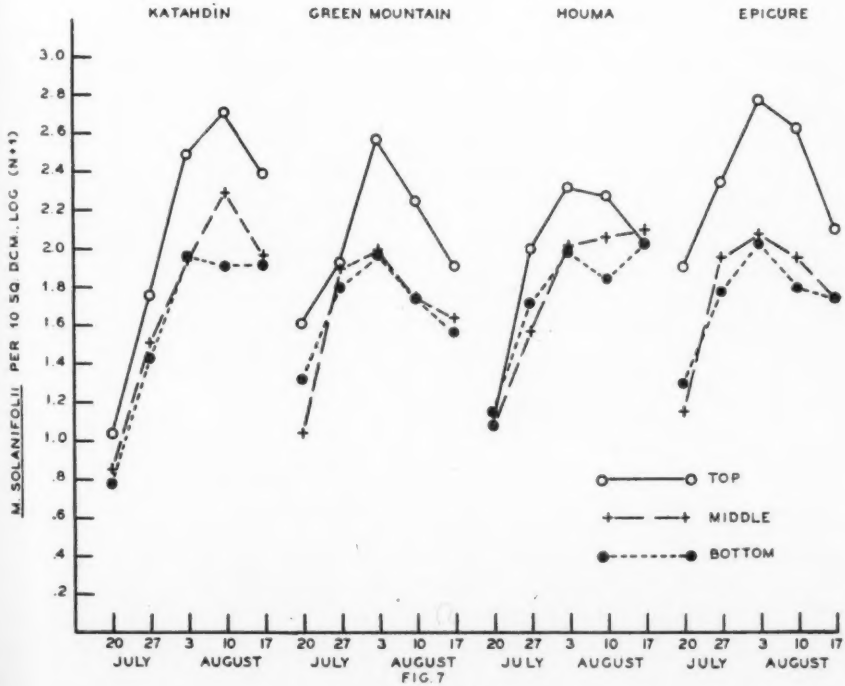
KATAHDIN
GREEN MOUNTAIN
HOUMA
EPICURE
TOP
MIDDLE
BOTTOM
M. SOLANIFOLII PER 10 SQ DCM., LOG (N+1)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
20 27 3 10 17
JULY
AUGUST

FIG. 7

August 3 and 10 the average number of *M. solanifolii* per plant on Epicure was nearly twice that on Houma (Fig. 5).

**Aphids per unit leaf area**

The number of each species of aphid per 10 square decimeters of top, middle, and bottom leaves on four varieties of potato, estimated during five weekly counts between July 21 and August 16, are represented graphically in Figs. 6, 7, and 8. Irish Cobbler was omitted because its early maturity made counts on it inaccurate after the first of August. In these figures the populations per 10 square decimeters of leaf area were transformed to the log $(n + 1)$ values, and this transformation was used in the analysis of variance of the results.

The results in Fig. 6 show that the bottom leaves supported the largest population of *M. persicae* per unit leaf area, and the top leaves the smallest. This was so on all four varieties, and the rate of population increase as shown by the slopes of the curves was approximately the same on these varieties. On August 10, the population on the bottom leaves of Katahdin was more than three times as great as the corresponding population on Epicure; at this time the ratio of *M. persicae* on the top, middle, and bottom leaves respectively varied from 1:5:8 on Katahdin to 1:1:2 on Epicure. There were no significant differences between varieties, but the differences between leaf positions and counting dates were both significant at the one per cent level.

The distribution of *M. solanifolii* (Fig. 7) differed from that of *M. persicae*. *M. solanifolii* was most abundant on the top leaves and less abundant on the middle and bottom leaves. The differences between the numbers of *M. solanifolii* on the middle and bottom leaves were small, and the population increase on these leaves was similar on all four varieties. On the top leaves, the number of *M. solanifolii* per unit leaf area differed for each variety; Epicure supported the largest population per unit leaf area, and Houma the smallest. The population of *M. solanifolii* reached a peak on Green Mountains, Houma, and Epicure on August 2 and on Katahdin a week later. On August 2 the ratio of *M. solanifolii* on the top, middle, and bottom leaves varied from 6:1:1 on Epicure to 2:1:1 on Houma. The differences between varieties, leaf positions, and counting dates were all significant at the one per cent level.

The distribution of *A. abbreviata* (Fig. 8) was similar to that of *M. persicae*. *A. abbreviata* was most abundant on the bottom leaves and least abundant on the top. The numbers of *A. abbreviata* per unit leaf area on the middle and bottom leaves were approximately the same for Katahdin and Houma but differed on Green Mountain and Epicure, there being more aphids on the bottom leaves. The population of *A. abbreviata* was greatest on Epicure and Green Mountain and smallest on Katahdin and Houma. On August 17 the ratio of *A. abbreviata* on the top, middle, and bottom leaves varied from 1:79:70 on Houma to 1:3:8 on Epicure. The differences between varieties, leaf positions, and counting dates were all significant at the one per cent level.

The total aphid population per 10 square decimeters of leaf area is represented graphically in Fig. 9. This shows that the largest population per unit leaf area was found on the bottom leaves of each of the four varieties. The rate of population increase, as shown by the slopes of the curves, was similar for these varieties; at the peak populations on August 10, the largest number of aphids per unit leaf area was found on Katahdin and the smallest on Houma. In spite of these differences in the peak populations, analysis of the data (log $(n + 1)$ transformation) did not show any significant difference between varieties. The ratio of each species on the top, middle, and bottom leaves varied with each

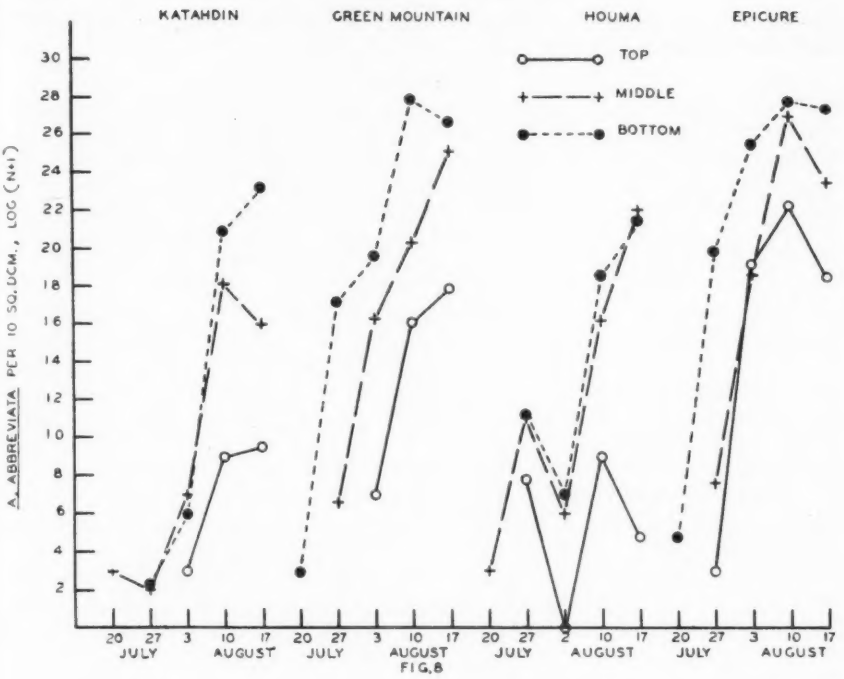
KATAHDIN
GREEN MOUNTAIN
HOUMA
EPICURE
TOP
MIDDLE
BOTTOM
A. ABBREVIATA PER 10 SQ.DCM., LOG (N+1)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
20 27 3 10 17
JULY
AUGUST
2

FIG.8

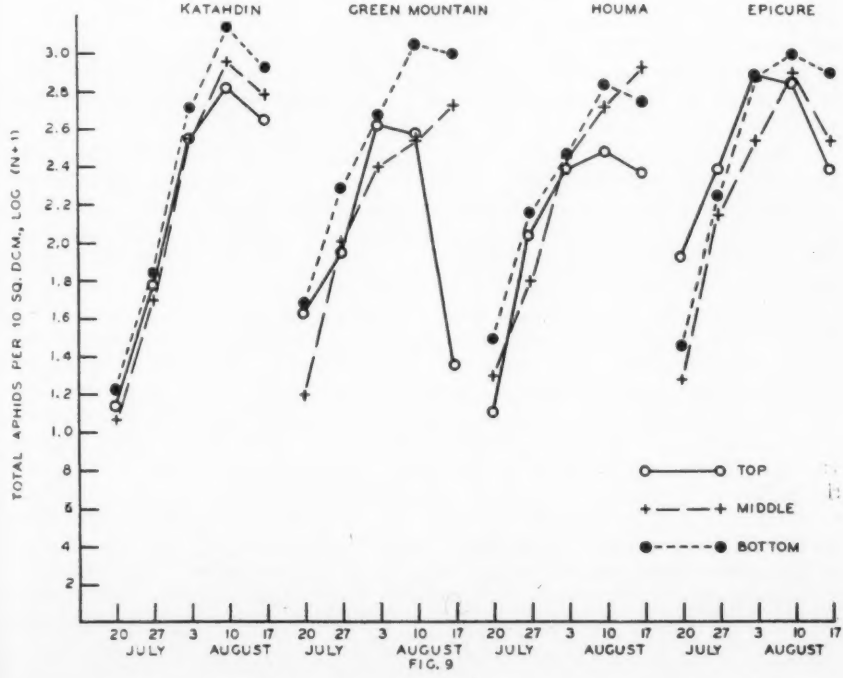
KATAHDIN
GREEN MOUNTAIN
HOUMA
EPICURE
TOP
MIDDLE
BOTTOM
TOTAL APHIDS PER 10 SQ. DCM., LOG (N+1)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
8
6
4
2
20 27 3 10 17
JULY
AUGUST

FIG. 9

count; these variations were not consistent and may have been due to sampling and counting errors.

## Discussion

When aphids are counted on equal numbers of top, middle and bottom leaves on potatoes and the population is expressed as aphids per 100 leaves, comparisons of populations for different varieties or dates of planting may give misleading results because of differences in leaf or plant size, and differences in the distribution of species of aphids on the plant. For example, a 100-leaf sample from Houma has nearly twice the leaf area of a 100-leaf sample from Epicure; yet sometimes the total leaf area of an Epicure plant is greater than that of a Houma plant. Often differences in aphid populations expressed as aphids per 100 leaves disappear or are modified when the populations are expressed as aphids per plant. When one compares the populations of aphids on different varieties of potato or potatoes grown under different conditions, expressing the population as aphids per plant is better than expressing it as aphids per 100 leaves. This conclusion agrees with that of Broadbent (1948) in England. However, in experiments where the areas of leaves and numbers of leaves per plant are similar in all plots, populations expressed as aphids per 100 leaves may be comparable.

Anscombe (1948) suggested that a more accurate estimate of the number of aphids per plant could be obtained by sampling top, middle, and bottom leaves in the ratios these are found on the plant. In the experiment at Woodstock, five weekly mid-season leaf counts on five varieties of potato (five plants per variety each week) showed that the ratio of top to middle to bottom leaves was similar for all these varieties and was about 6:2:1. Since the small top leaves in the terminal rosette sometimes become heavily infested, these were included in the top leaf counts and a portion of them was sampled; the young axillary shoots from the middle and bottom portions of the plant whose leaves approximated the top leaves in physiologic age and appearance were also counted and sampled as top leaves. By this method of counting the leaves, a more accurate estimate of the aphids per plant would probably be obtained by counting the aphids on five times as many top leaves as on either middle or bottom leaves. Such a change in the sampling would be practicable, as top leaves are the easiest to count; they are smallest in size and usually have the lightest infestations.

Bald, Norris, and Helson (1950) suggested dividing the plant into basal, ground canopy, middle, and top leaves and sampling in succession one of each of these. Though for many purposes sampling equal numbers of top, middle, and bottom leaves and expressing the population as aphids per plant is satisfactory, further divisions of the leaves and more careful sampling should give more accurate estimates of the population per plant.

Expressing the population as aphids per unit leaf area eliminates differences due to leaf size that occur when the population is expressed as aphids per 100 leaves, but differences in plant size and the distribution of species of aphids on the plant may make comparisons between varieties and/or dates of planting misleading. For example, two varieties differ in that the leaf area of a plant of A is twice that of a plant of B. The population per plant is the same for both varieties, and is distributed uniformly over the leaf areas of A and B. Whereas the population per plant is the same for these two varieties, the population per unit leaf area of A is only half that of B. The distribution of aphids on the plant usually differs for each species; and because of differences in the sizes of top, middle, and bottom leaves, a study of such distributions necessitates expressing the population as aphids per unit leaf area. In Australia, Bald, Norris, and Helson (1946) also expressed populations as aphids per unit leaf area when studying the

field spread of potato leaf roll; and in England, Kennedy, Ibbotson, and Booth (1950) used aphids per unit leaf area to study the distribution of *M. persicae* and *Aphis fabae* Scop. on *Beta vulgaris* L. and *Euonymus europaea* L. The distribution of *M. persicae* on potatoes in New Brunswick is similar to that reported in other countries. Simpson (1940) in Maine, Jacob (1941) in Wales, and Norris and Bald (1943) in Australia all found *M. persicae* more numerous on the bottom than on the middle or top leaves of potatoes. The preference of *M. solanifolii* for the top leaves on potatoes was also reported in Virginia (Smith, 1919). In Australia, however, Norris and Bald (1943) found that, like *M. persicae*, *M. solanifolii* was most abundant on the bottom leaves. They suggested that the hot, dry climate around Canberra causes the aphids to seek shelter on the bottom leaves. An observation made while counting aphids at Woodstock supports this hypothesis. It has been noticed repeatedly that *M. solanifolii* is abundant on the top leaves in the cool morning but less abundant in the afternoon when it is hot and dry. This suggests a daily movement of *M. solanifolii* upon the plant that may be an important factor in the spread of viruses. That *A. abbreviata* is more abundant on the bottom leaves of potatoes was also reported in Maine (Simpson, 1940).

Some species of aphids appear to thrive better on some varieties of potato than on others; but a low population of one species does not always mean that the variety is resistant to all species of aphids. For example, in the field experiment at Woodstock in 1949 a much higher population of *M. persicae* was found on Katahdin than on Epicure; however, Epicure supported a much larger population of *A. abbreviata* than Katahdin. On the other hand, Houma appeared to support a lower population of each of the three species of aphids than the other four varieties. Broadbent (1950) reported that environmental conditions vary at different levels in the potato foliage. Such variations in microclimate may be a factor determining the distribution of species on the plant, and may be the reason why some species thrive better on some varieties than on others.

The total aphid population per unit leaf area (Fig. 9) shows that aphids were most numerous on the lower leaves. This emphasizes the importance of obtaining adequate coverage, particularly of the lower leaves, when attempting to control aphids with insecticides.

**Summary**

On the basis of equal numbers of top, middle, and bottom leaves, the areas of 100-leaf samples from varieties of potato such as Houma and Epicure differed by as much as a factor of two. When aphids were counted on equal numbers of top, middle, and bottom leaves, and the population was expressed as aphids per 100 leaves, some of the recorded differences in populations between varieties were due to differences in the areas of the leaf samples. Such differences in recording the aphid populations are often modified when the populations are expressed as aphids per plant.

On the basis of aphids per unit leaf area, the distributions of three species of aphid on the plants of four varieties of potato were investigated. On Katahdin, Green Mountain, Houma, and Epicure, *M. persicae* and *A. abbreviata* were most numerous on the bottom and least numerous on the top leaves, whereas *M. solanifolii* were most numerous on the top leaves of plants of these varieties.

**Acknowledgments**

The help of Mrs. P. H. Baird and of Mr. R. Y. Ganong in the aphid counting is gratefully acknowledged. Mr. Ganong also assisted in the analysis of data and drafted the graphs.

## References


Adams, J. B. 1946. Aphid resistance in potatoes. *American Potato* 23: 1-22.

Anscombe, F. J. 1948. On estimating the population of aphids in a potato field. *Ann. Appl. Biol.* 35: 567-71.

Bald, J. G. 1943. Estimation of the leaf area of potato plants for pathological studies. *Phytopathology* 33: 922-32.

Bald, J. G., D. O. Norris, and G. A. H. Helson. 1946. Aphid populations, resistance and tolerance of potato varieties to leaf roll. *Australian Coun. Sci. Ind. Res. Bull.* 196.

Bald, J. G., D. O. Norris, and G. A. H. Helson. 1950. Transmission of potato virus disease. *Australian Jour. Agr. Res.* 1: 18-32.

Broadbent, L. 1948. Methods of recording aphid populations for use in research on potato virus diseases. *Ann. Appl. Biol.* 35: 551-66.

Broadbent, L. 1950. The microclimate of the potato crop. *Roy. Meteor. Soc.* 76: 439-54.

Davies, W. M. 1934. Studies on aphides infesting the potato crop. Aphid survey: its bearing upon the selection of districts for seed potato production. *Ann. Appl. Biol.* 26: 116-34.

Doncaster, J. P., and P. H. Gregory. 1948. The spread of virus diseases in the potato crop. *Agr. Res. Coun. Report Series* 7. London: H.M.S.O.

Hansen, H. P. 1941. Studier over Kartoffelviroser I. *Danmark* III.

Heinze, K., and J. Profft. 1940. Uber die an der Kartoffel lebenden Blattlausarten und ihren Massenwechsel im Zusammenhang mit dem Auftreten von Kartoffelvirosen. *Mitt. Biol. Anst.* (*Reichsanst*). Berlin 60.

Jacob, F. H. 1941. The over-wintering of *Myzus persicae* Sulz. on Brassicae in North Wales. *Ann. Appl. Biol.* 28: 119-24.

Jacob, F. H. 1944. A two years' survey of the potato aphides in the Northern Agricultural Advisory Province. *Ann. Appl. Biol.* 31: 312-19.

Joyce, R. J. V. 1938. On certain aspects of the feeding mechanism, feeding habits and ecology of the potato aphides, *Myzus persicae* Sulz. and *Macrosiphum gei* Koch, in relation to the dissemination of virus diseases of potatoes. Ph. D. thesis. University of Wales.

Kennedy, J. S., A. Ibbotson, and C. O. Booth. 1950. The distribution of aphid infestation in relation to leaf age. I. *Myzus persicae* (Sulz.) and *Aphis fabae* Scop. on spindle trees and sugar-beet plants. *Ann. Appl. Biol.* 37: 651-79.

Moericke, V. 1941. Zur Lebensweise der Pfirsichlaus (*Myzodes persicae* Sulz.) auf der Kartoffel. Ph. D. thesis. University of Bonn.

Münster, J. 1948. Recherches sur les pucerons de la pomme de terre. La frequence en suisse romande de pucerons vecteurs de maladie à virus. *Mitt. Schweiz. Ent. Ges.* 21: 159-165.

Norris, D. O., and J. G. Bald. 1943. Transmission of potato virus disease. 2. The aphis population of potatoes at Canberra during 1940-41. *Australian Coun. Sci. Ind. Res. Bull.* 163.

Simpson, S. W. 1940. Aphids and their relation to the field transmission of potato virus diseases in north-east Maine. *Maine Agr. Expt. Sta. Bull.* 403.

Smith, L. B. 1919. The life history and biology of the pink and green aphid (*Macrosiphum solanifolii* Ashmead). *Virginia Truck Expt. Sta. Bull.* 27.

Staniland, L. N. 1943. A survey of the potato aphids in the South-western Agricultural Advisory Province. *Ann. Appl. Biol.* 30: 33-42.

Thirmalachy, N. C. 1940. A rapid method of measurement of leaf areas of plants. *Indian Agr. Sci.* 10: 835-41.

Thomas, I., and F. H. Jacob. 1943. Ecology of the potato aphides in North Wales. *Ann. Appl. Biol.* 30: 97-101.

Whitehead, T. 1943. Some factors influencing the health of seed potatoes in North Wales. *Ann. Appl. Biol.* 30: 85-96.

# Observations on the Biology and Control of Pest Trichoptera at Fort Erie, Ontario[1]

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The community of Fort Erie, Ontario, and the waterfront zone of Buffalo, New York, form one of the many areas in the St. Lawrence River drainage system that are annually infested by large numbers of adult Trichoptera and, to a lesser degree, Ephemerida. Betten (1934) reported on a field study, conducted in 1906, of the Trichoptera found at Buffalo, N.Y. He noted the prevalent species and the extent of the problem that the insects create for the local inhabitants. The medical aspect was investigated by Parlato (1929, 1930, 1932) and Osgood (1934). In August, 1950, an investigation of the scale, composition, and source of the trichopteran infestation and possible control measures was initiated at Fort Erie, Ontario.

Fort Erie and Buffalo are situated on opposite banks of the Niagara River, near its efflux from Lake Erie (Fig. 1). The river is approximately half a mile wide at this point and has a rapid current over a bed of rock, gravel and sand. At the northern limits of the town the current is reduced and the river is divided by Strawberry Island, a small gravel bar. A few hundred yards farther downstream the river is divided by Grand Island. A prominent feature on the Canadian side is a rock shelf, 20 to 30 yards wide, which extends along the shoreline from Erie Beach Pier to the Peace Bridge. This shelf, under several feet of water, is partially covered by stones and gravel.

The adult caddisflies are reported to make their first appearance each year at the middle of June, and to persist until late fall. Large numbers of the insects were observed during the first few days of the survey, in the second week of August; on the evening of August 15 an enormous increase occurred that persisted until August 26, when the survey was concluded. Hence there was an opportunity to observe the infestation at its peak and the nuisance problem that developed each evening during that period. Dense swarms of the insects formed over trees and other tall objects a few hours before sunset; these swarms slowly united to form a mass movement upstream in the direction of the lake, blanketing the area bordering the river to a distance of 1,000 yards from the water and extending upwards to an estimated height of 300 feet. The density of this flight is indicated by the collection of an estimated 6,800 specimens with 10 sweeps of a net. The area covered by this flight is shown in the accompanying map (Fig. 1).

The insects are strongly attracted to light, and tremendous numbers collected about lights on the streets, at homes, and about hotel and theatre marquees and other establishments. The flight diminished slowly, and two hours after sunset the main movement had ceased. In the morning, piles of dead insects were found below street lamps and other sources of illumination. The surviving adults sheltered during the daylight hours in the foliage of trees and shrubs and in tall grass. General collections in these places yielded many mating pairs.

The annoyance created in a community by invasions of these pests includes the complete restriction of all exterior decorating during the summer months; the filth and stench of the masses of dead insects; the necessity, when one drives through the community during the evening flight, of observing the caution

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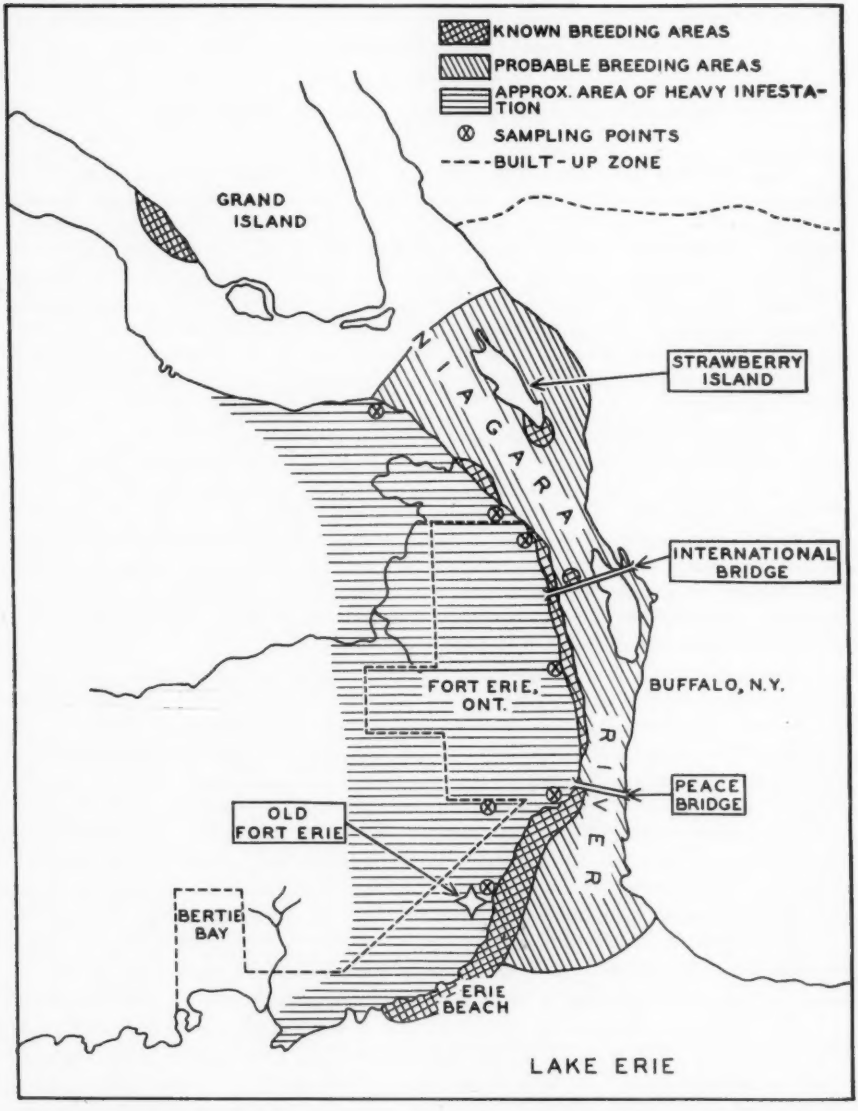


FIG. 1. Map of the Fort Erie, Ontario, area showing details concerning the caddisfly infestation.

normally reserved for dense fog; and the allergic reaction suffered by hypersensitive individuals, locally termed "sandfly fever".

Although the entire river bed could not be examined because of the depth and swift flow of the river, the preliminary survey indicated that the breeding areas occur under the rapid waters of the river, opposite the built-up area of Fort Erie, that is, from the efflux of the river from Lake Erie to Strawberry Island.

No significant numbers of larvae or pupae were found on the Canadian side of the river downstream from Strawberry Island to Niagara Falls, or on the lakeshore west of Erie Beach Pier. Heavy infestations were found along the entire length of the rock shelf, and in the shallower waters near the shoreline downstream to the northern limits of Fort Erie. The upstream shoreline of Strawberry Island and its underwater extensions were densely infested. The heaviest concentration was found on rocks and gravel taken from a depth of six to 10 feet of water beneath the International Bridge. The river bed at this point was believed to be typical. The United States shore was not examined, but the finding of an isolated breeding area on the west shore of Grand Island may indicate that other breeding areas may occur on that side of the river.

The identification of the specimens collected by the author and his assistants and by two other parties in the same season was reported by Munroe (1951). The composition of the samples of the larvae and pupae from the Niagara River and the complete dominance of species characteristic of rapid streams suggested to Dr. Munroe that all the Trichoptera of the Fort Erie region breed in the Niagara River.

The larval and adult collections indicate that the main pest species is *Hydropsyche bifida* Walker. Over 80 per cent of the identified larval specimens were of the *bifida* and *scalaris* groups of the genus, which outnumbered the genus *Cheumatopsyche*, the next most abundant, by over three to one. Certain other hydropsychids, and certain leptocerids, limnophilids, and hydrotilids were present in insignificant numbers, the last two groups being restricted to the quiet waters at Erie Beach. Munroe reported that *H. bifida* constituted over 70 per cent of the total adult collections and, with *Oecetic avara* Banks, *Hydropsyche placoda* Betten, and *Neureclipsis crepuscularis* Walker, made up more than 90 per cent. Adults of *O. avara* reached a peak of abundance on August 4-5; this explains the absence of this species from the larval collections, and the abundance of cheumatopsychid larvae in the Niagara River and the low adult population suggest that the peak of the cheumatopsychids had not been reached by August 26. Both *N. crepuscularis* and *Macronemum zebratum* Hagen were well represented in the adult collections, with no marked fluctuations, and yet very few larval specimens were obtained. Extension of the river survey would probably uncover the breeding areas of these two species.

The development of a practical control program would require considerably more data on the biologies of the local species of Trichoptera than are available. However, the concentration of the immature stages within such a limited area, and the restricted distribution of the adults, suggested vulnerability to insecticide applications. Because Trichoptera are important in the biological balance in streams and ponds, there is a lack of information on the effect of insecticides against them. It is probable that a high concentration of certain insecticides, e.g., DDT, would eliminate the larvae of Trichoptera. The advisability of such an application is doubtful, in view of the importance of Trichoptera in the biological balance in the Niagara River, and the probability that other life in the river would be adversely affected as well as the pest insects.

It was considered that control directed against the adult insects by any means would not be so effective as to reduce the numbers of the immature stages in the river to a degree detrimental to fish and other water life. There is no direct evidence to support this; but until evidence to the contrary is presented, it may not be illogical to assume that the incomplete reduction in adult numbers afforded

by control measures would, with lessened competition for existence, permit sufficient oviposition to maintain the fish and other fauna that feed upon the immature stages. Accordingly, the possibility of reducing the adult infestation was investigated. The sole method of protection employed previously was the use of amber lights, which do not attract the insects.

Chemical control, by means of a DDT aerosol applied from a TIFA generator, was evaluated during the peak of abundance of the adults. A 5 per cent (wt./wt.) solution of technical DDT in domestic fuel oil was applied at 1.1 pounds of DDT per 1,000 feet of frontage, from a generator moving at 1 to 2 m.p.h. Three field experiments, in which caged specimens of *Macronemum* spp. and *Hydropsyche* spp. were exposed to the aerosol, resulted in 100 per cent mortality 15 minutes after exposure. Further field experiments were carried out against dense infestations of these species on isolated groups of fruit trees. The aerosol caused an immediate increase in the activity of the insects followed rapidly by death; the infestation on the trees was almost eliminated and the grass below was blanketed with the dead insects.

The habits of the insects and the narrow limits of meteorological conditions suitable to aerosol applications prevented these favourable results from being repeated on a large scale. Fully satisfactory meteorological conditions usually occur only during the hours of sunset and sunrise. At sunset the evening flight was at its peak, and applications of the aerosol into this mass of insects had no noticeable effect on the vast numbers. During the remaining hours of the day the aerosol was effective in the areas that could be reached, but the majority of of sheltering places, such as tall trees, woods, and other inaccessible sites, provided complete protection for the insects. Certain of these places were sprayed with the DDT solution by portable pressure sprayers, and the residual effect of the insecticide persisted for three to four days.

## Summary

The main source of the annual caddisfly infestation of the Fort Erie area and the waterfront of Buffalo, N.Y., is the Niagara River.

The elimination of the larvae from the river is not considered practical or advisable in view of the importance of these insects in the maintenance of the balance of nature in the river. However, it is probable that they could be removed by a larvicide such as DDT; it is also probable that such an application would eliminate other living forms.

A solution of 5 per cent DDT in fuel oil applied as an aerosol or a spray was effective against the adult insects in field experiments. Large-scale control by aerosol applications was not attempted. More data are needed on the biology of the species, including time and period of emergence, mating and oviposition habits, and the duration of the life-cycle.

## Acknowledgments

Acknowledgment is made of the valued assistance of Messrs. Paul E. Morrison and David L. Watson, Household and Medical Entomology, Ottawa; and of the co-operation of Mr. R. H. Sheppard, District Inspector, Division of Plant Protection, Canada Department of Agriculture, Niagara Falls, Ontario; Messrs. H. E. Thompson, A. E. Jepson, and R. G. Dadson, of the Fort Erie Lion's Club; and Mr. Melvin E. Attrill, Ontario Veterinary College, Guelph, Ontario.

**References**

Betten, C. 1934. The caddis flies or Trichoptera of New York State. *New York State Mus. Bull.* 292.

Munroe, E. G. 1951. Pest Trichoptera at Fort Erie, Ontario. *Canadian Ent.* 83: 73-76.

Osgood, H. 1934. Comparison of reagins to separate species of caddis fly. *J. Allergy* 5: 367.

Parlato, S. J. 1929. Case of coryza and asthma due to sandflies (caddis flies). *J. Allergy* 1: 35.

Parlato, S. J. 1930. Sand fly (caddis fly) as an exciting cause of allergic coryza and asthma. *J. Allergy* 1: 307.

Parlato, S. J. 1932. Emanations of flies as exciting causes of allergic coryza and asthma. *J. Allergy* 3: 459.

Ross, H. H. 1944. The caddis flies, or Trichoptera, of Illinois. *Illinois Nat. Hist. Survey Bull.* 23.

## *Psila nigricornis* Meig. (Diptera: Psilidae), a New Pest of Possible Economic Importance

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In February, 1951, specimens of chrysanthemum stools received from a nurseryman near Sardis, British Columbia, were found to be injured by maggots. Examination showed dipterous larvae feeding in channels bored in the centres of the roots, crowns, and new shoots.

As available literature contained no reference to an insect having this habit in chrysanthemums, material was caged for rearing. Adults began emerging on March 17, and were determined by Mr. J. F. McAlpine, Systematic Entomology, Division of Entomology, Ottawa, as *Psila nigricornis* Meig. This was a new record for North America.

Literature on the species is meagre, but it was recorded in England as occurring in carrot fields by Collin (1944. British species of Psilidae. Ent. Mon. Mag. 83: 223-224). However, it is not recorded as a pest of economic importance on carrots in England. Records of damage caused by this insect are given by Kearns and Walton (1932. *Psila nigricornis* Meig. as a pest of chrysanthemums. *In* Ann. Rept. Agr. and Hort. Res. Sta., Long Ashton, Univ. Bristol, pp. 86-96) and H. W. and M. Miles (1935. Insect pests of glasshouse crops, pp. 35-36. London).

Recent correspondence with Mrs. Mary Miles, root maggot specialist at Wye College, Kent, England, shows that it is a well-known pest of chrysanthemums under glass in England and that it also infests lettuce where this is grown following chrysanthemums, causing serious damage to both crops. Mrs. Miles considers it a pest only of the Compositae, and suspects its occurrence in carrot fields may be due to the presence of weeds of that family.

It is distinguishable from *Psila rosae* (F.), the carrot rust fly, only by minute characters, most significant of which are genitalic differences. Other characters concern the hairs behind the front femora, the length of the aristal pubesence, and the size and shape of the eyes, cheeks, and jowls. The colour of the third antennal segment is also of some value in separating these two species; it is always black in *P. nigricornis* but usually yellow or partly so in *P. rosae*.

# Key to the Puparia of the Dipterous Parasites of *Choristoneura fumiferana* Clem.[1]

*By* D. A. Ross[2]

The frequent failure of parasite development beyond the immature stages during insectary rearing work often results in incomplete qualitative and quantitative data on insect parasites. Keys to the larval and pupal stages are therefore an extremely useful aid in completing the picture in a study of a parasite complex.

The following illustrated key makes it feasible to obtain reasonably accurate specific determinations of the puparia of the dipterous parasites of the spruce budworm, *Choristoneura fumiferana* Clem., that occur in Canada. The writer gratefully acknowledges the inspiration and co-operation of A. R. Brooks during the preliminary preparations for the key. The illustrations were executed by Miss M. MacKay (Figs. 1-14) and B. Sugden (Fig. 15). Each figure illustrates the following: (a) posterior aspect of a puparium showing the location of the stigmal plates and the anal aperture, and any protuberances that are present; (b) one stigmal plate and the stigmal slits; (c) lateral aspect of the outline of a puparium.

## Key to Puparia of Dipterous Parasites of Spruce and Jack Pine Budworm

1. Spiracles in a deep cavity, partly hidden from view ..... Group A
   Spiracles not in cavity ..... 2
2. Four slits in each stigmal plate ..... Group B
   Three slits in each stigmal plate ..... Group C

### Group A

*Spiracles in a deep cavity*

1. Opening of cavity, circular, fairly smooth edge ..... (Fig. 1) *Pseudosarcophaga affinis* (Fall.)
   Opening of cavity broadly elliptical, edge sculptured ..... (Fig. 2) *Sarcophaga aldrichi* Park.

### Group B

*Four slits in each stigmal plate*

1. Spiracular slits only slightly curved ..... 2
   Spiracular slits serpentine; shallow protuberance ventrad to stigmal plates ..... 3
2. Stigmal plates protruding; slits, oblique, sometimes fourth slit much reduced ..... (Fig. 3) *Phorocera incrassata* Sm.
   Stigmal plates only slightly raised, stigmal slits almost horizontal ..... (Fig. 4) *Phorocera erecta* Coq
3. Small, shallow, darkly pigmented swelling dorsad to stigmal plates; central portion of stigmal plate lighter in colour than the bevelled edge ..... (Fig. 6) *Madremyia saundersii* (Will.)
   Dorsal swelling absent; stigmal plate apparently uniformly black ..... (Fig. 5) *Phryxe pecosensis* (Tns.)

### Group C

*Three slits in each stigmal plate*

1. Stigmal plates borne on a broad column ..... (Fig. 7) *Actia interrupta* Curr.
   Stigmal plates not borne on a column ..... 2
2. Spiracles situated at a distance at least three times the diameter of the stigmal plate above the horizontal axis of the puparium; stigmal plates flush with the surface of the puparium ..... (Fig. 10) *Tachinomyia nigricans* Webb.
   Spiracles situated at a distance less than three times the diameter of the stigmal plate above the horizontal axis of the puparium ..... 3
3. Stigmal plates small, encircled by a groove; puparium rugose, no protuberances ..... (Fig. 9) *Lypha setifacies* (West)
   Stigmal plates medium to large, not encircled by a groove, protuberances generally present 4

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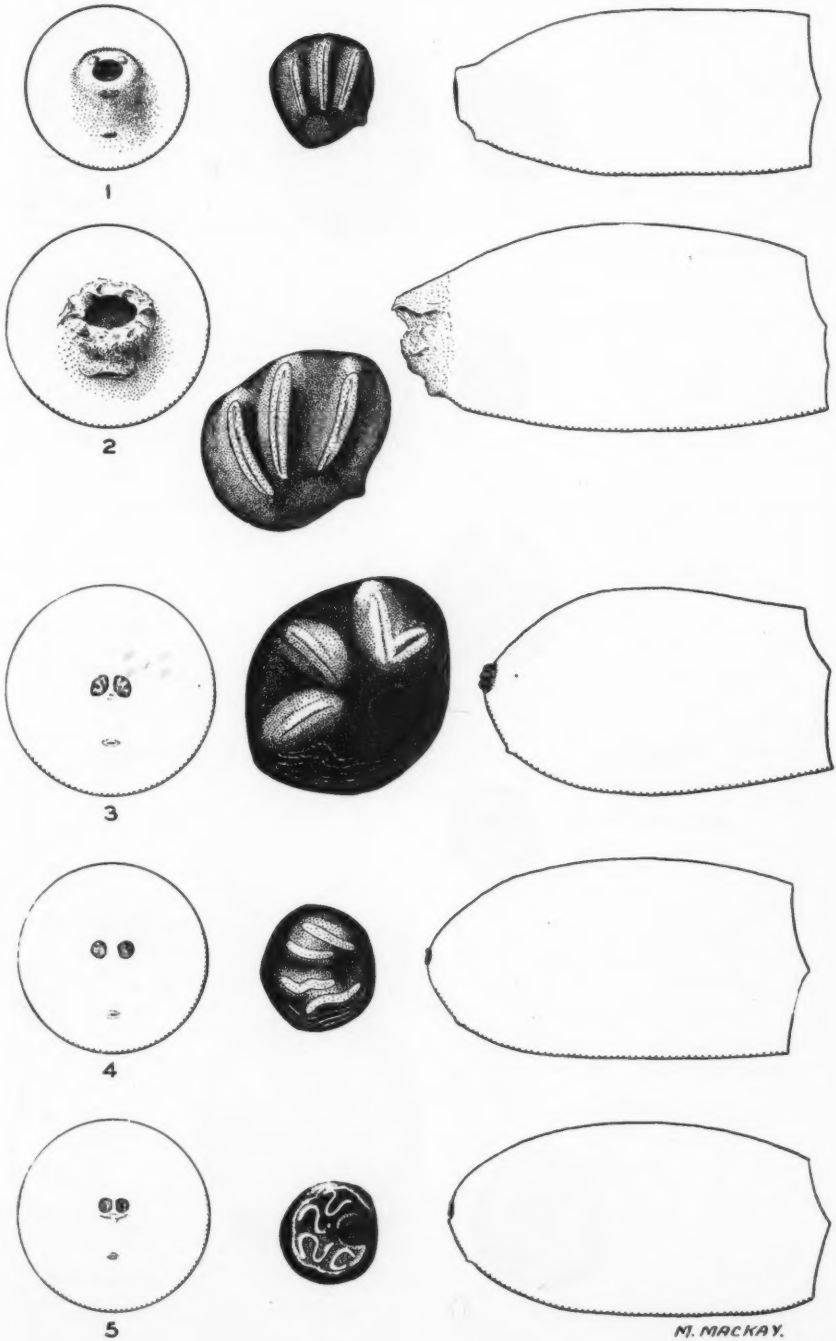
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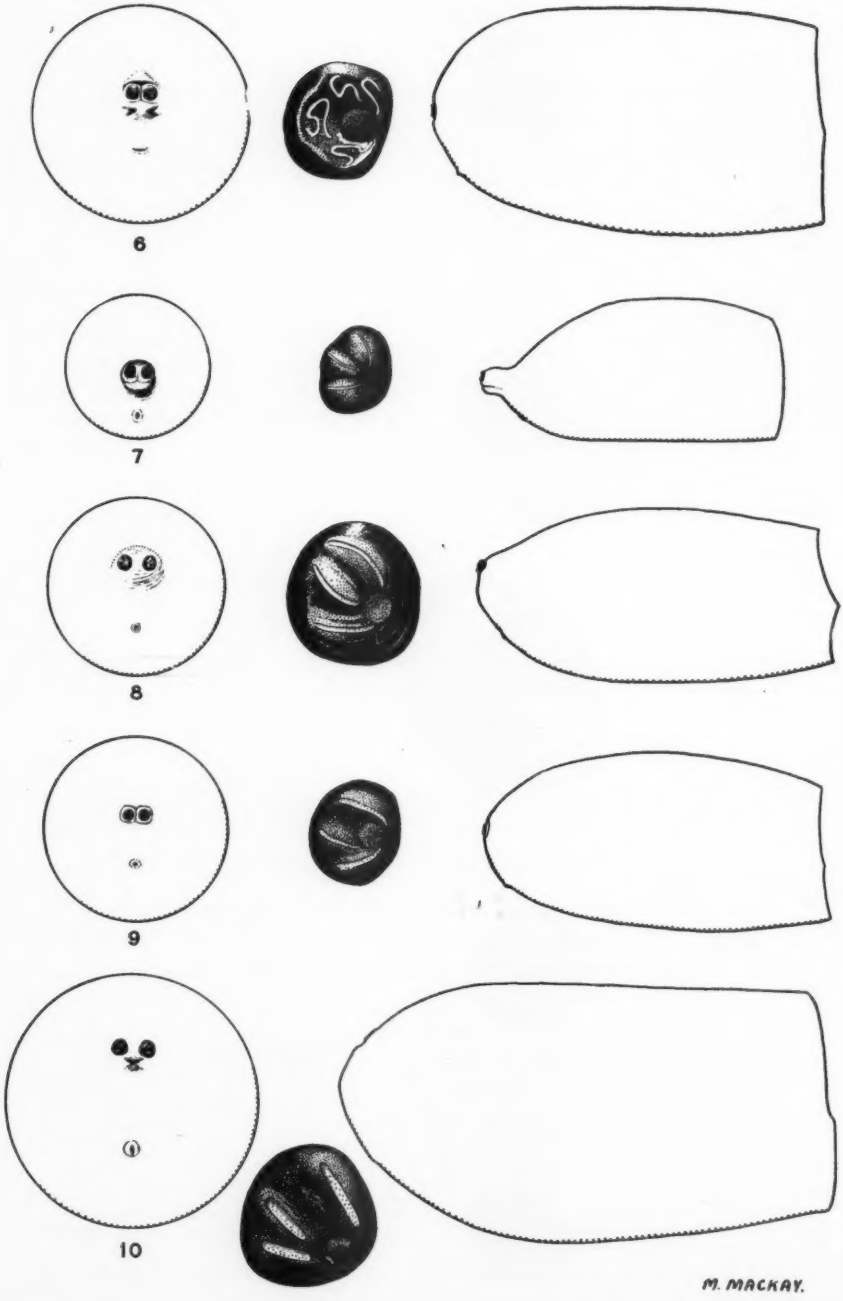
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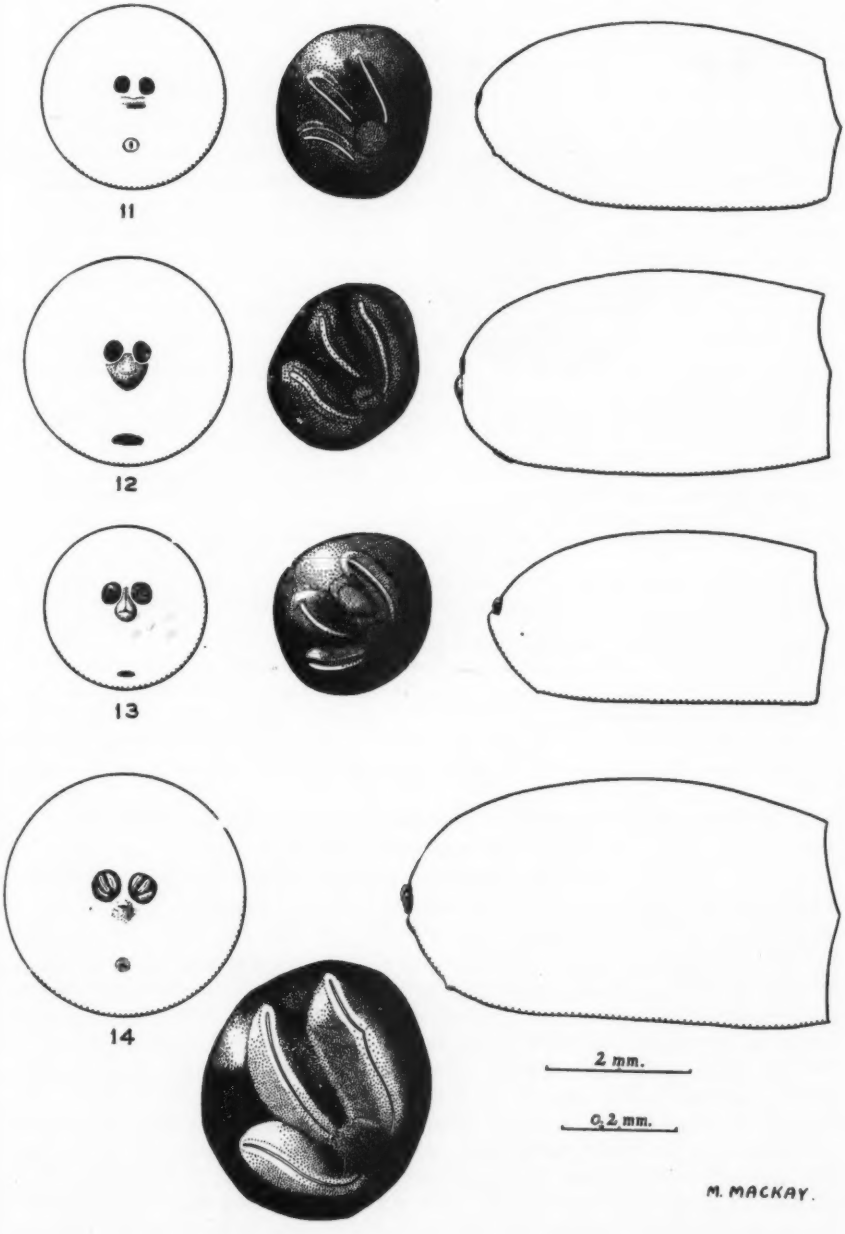
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2 mm.
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M. MACKAY.

4. Puparium slightly depressed above the stigmal plates and broadly rounded beneath; stigmal plates protruding, directed upward slightly ..... (Fig. 8) *Nemorilla pyste* (Wlk.)
Puparium not as above ..... 5
5. Protuberance (usually present) ventrad to stigmal plates very small; stigmal plates only slightly raised; puparium glossy ..... (Fig. 11) *Aplomya caesar* (Ald.)
Protuberance ventrad to stigmal plates prominent ..... 6
6. Stigmal plates not protruding, only slightly raised; slits on very small ridges ..... (Fig. 12) *Omotoma fumiferanae* (Tll.)
Stigmal plates protruding; slits on prominent ridges ..... 7
7. Protuberance usually juts out beyond the stigmal plates, ridges bearing stigmal slits broadly rounded ..... (Fig. 13) *Phorocera tortricis* Coq.
Protuberance shallower than the stigmal plates ..... 8
8. Ridges bearing long stigmal slits, narrow distally and broad at the base ..... (Fig. 14) *Ceromasia aurifrons* Tns.
Ridges bearing short stigmal slits, broadly rounded, not as prominent as in *Ceromasia aurifrons* ..... (Fig. 15) *Ceromasia auricaudata* Tns.

## A Note on a Dipterous Predator of the Onion Maggot, *Hylemya antiqua* (Meig.)

*By* J. P. Perron and J. Lafrance
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In investigations on the life-history of the onion maggot at St. Jean, Que., in 1951, a few specimens of a dipterous predator were found in the rearing cages in the laboratory. They were feeding voraciously on the adults, destroying a colony of nearly 300 flies within two weeks.

Specimens were identified by Mr. A. R. Brooks, Systematic Entomology, Division of Entomology, Saskatoon, Sask., as *Coenosia tigrina* (F.). Mr. G. E. Shewell, Systematic Entomology, Division of Entomology, Ottawa, has stated that nothing is known in Canada about the life-history of this species, but that it is apparently well known as a predator in Europe and that B. M. Hobby* has published a long list of species on which it preys, including many anthomyiids.

This is the first Canadian record of *C. tigrina* as a predator of the adult of the onion maggot.

*Proc. Ent. Soc. London 6, 1931, pp 13-15.

# Some Effects of Various Food Plants on *Melanoplus mexicanus mexicanus* (Sauss.) (Orthoptera: Acrididae)[1]

*By* D. S. Smith[2], R. H. Handford[3], and W. Chefurka[4]
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## Introduction

The long-held belief that grasshoppers are to a large extent omnivorous and, as Wolcott (1936) states, "like cows, feed on any kind of vegetation", is slowly giving place to the view that they are much more restricted feeders. Their habit of nibbling at almost anything, particularly when they are present in large numbers, probably led to this erroneous concept. More recent work such as that of Rubtzov (1931), Criddle (1933), and Isely (1938, 1944, 1946) stresses the fact that many species of grasshopper confine their feeding to a group of related plants, and a few species to a single plant.

Investigations were undertaken at the Field Crop Insect Laboratory at Brandon, Manitoba, to compare the effects of various plant species on the survival and fecundity of the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.), each plant species forming the sole source of food throughout three successive generations of the grasshopper. Because the first season's work, in 1944, was of an exploratory nature and was conducted in a greenhouse, only the work of 1945 and 1946, when the rearing was done in cages outdoors, will be discussed.

## Materials and Methods

The food plants used were dandelion, brome grass, Russian thistle, alfalfa, sweet clover, flax (Royal), oats (Vanguard), wheat (Renown), and barley (Plush). The first five were growing wild in vacant lots in the vicinity of the laboratory. The others were grown in flats outdoors. Those in the flats were replanted several times so that the plants as fed were young and succulent. Whenever possible younger plants or new growth of those plants growing wild were used for feeding, but later in the season it became difficult to do this with brome and, to a lesser extent, with clover and alfalfa, and more mature growth had to be used.

The cages used were 2-qt. sealers with the glass top replaced by wire mesh screening and with an inch or two of soil in the bottom. They were kept outdoors but partly shielded from rain and hot sun.

The cages were stocked with newly hatched nymphs of *M. m. mexicanus*, 10 nymphs in each cage, and 5 cages for each food plant. In 1944, nymphs from field-collected eggs had been used; their progeny was the source of material for the 1945 tests, and the progeny from 1945 was used in 1946. Each generation was fed on the same food plant as its parents.

The grasshoppers were fed with cuttings from the food plants two to four times daily to ensure an adequate supply of fresh food. Daily records were kept of the number of nymphs that died and of those that moulted. When the grasshoppers became adult those on each food were distributed so that there were approximately equal numbers of males and females in each cage. Rearing was continued until oviposition ceased. Egg pods were sifted from the soil in the cages, and the eggs were counted.

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## Results

Table I shows the percentage of individuals that survived to the adult stage in each year on each food plant. For many of the food plants the figures are reasonably consistent for the two years. The survival on Russian thistle, how-

TABLE I.
Percentages of *M. m. mexicanus* surviving to adult stage on various food plants, Brandon, Manitoba, 1945 and 1946.

| Food Plant | Percentage Survival | | |
|---|---|---|---|
| | 1945 | 1946 | Average* |
| Dandelion | 60 | 70 | 65 |
| Barley | 66 | 56 | 61 |
| Wheat | 56 | 54 | 55 |
| Brome | 50 | 48 | 49 |
| Flax | 56 | 40 | 48 |
| Sweet Clover | 64 | 28 | 46 |
| Russian thistle | 36 | 56 | 46 |
| Oats | 40 | 36 | 38 |
| Alfalfa | 38 | 2 | 20 |

*Least significant difference (5% level), 14.6.

TABLE II
Duration in days of nymphal period of *M. m. mexicanus* fed on various plants, 1945 and 1946.

| Food Plant | Nymphal Period, Days | | |
|---|---|---|---|
| | 1945 | 1946 | Average |
| Flax | 41 | 50 | 45.5 |
| Wheat | 43 | 48 | 45.5 |
| Dandelion | 43 | 50 | 46.5 |
| Oats | 47 | 51 | 49.0 |
| Russian thistle | 47 | 53 | 50.0 |
| Barley | 47 | 53 | 50.0 |
| Brome | 53 | 48 | 50.5 |
| Sweet clover | 47 | 57 | 52.0 |
| Alfalfa | 56 | 61* | 58.5 |

*One grasshopper only.

ever, reversed the general trend in being lower in 1945 than in 1946. In 1945 a heavy mortality occurred in the Russian thistle cages on one day when the temperature in the cages rose to about 110°F. Eight nymphs died in these cages that day; none died in any of the other cages. More died in the next few days and, during the next two weeks, the survival on Russian thistle declined from 70 to 44 per cent. No marked decrease in survival occurred on the other food plants during this period.

The survival on both sweet clover and alfalfa was much lower in 1946 than in 1945; on alfalfa only one individual, a female, became adult; two others reached the fifth instar but developed no further before dying at the end of the season.

Grasshoppers fed on dandelion showed the greatest survival, those fed on barley and wheat only slightly less; survival on oats was definitely low and on alfalfa the lowest of all.

The numbers of days from the time of hatching to the time when 50 per cent of the survivors had become adult on each food are shown in Table II. On most of the food plants this nymphal period lasted from 43 to 47 days in 1945 and from 48 to 53 days in 1946. It is probable that the differences in the nymphal periods on the different foods are of no significance except for alfalfa, on which it was noticeably longer in both years.

Females fed on wheat produced the greatest average number of eggs in the 2-yr. period (Table III). Those fed on barley and on dandelion also laid large numbers of eggs. Those fed on sweet clover, alfalfa, and Russian thistle produced the smallest numbers of eggs. For all foods except wheat there was a sharp decline in the number of eggs per female in 1946 compared with 1945.

The effect of these plants on *M. m. mexicanus* was assessed by computing the product of the average percentage survival and the average number of eggs per female, thus obtaining an index very similar to the *biotic potential* of Birch (1945) (Table IV). This product indicated that wheat was the most favourable

TABLE III

Numbers of eggs laid by *M. m. mexicanus* fed on various plants, 1945 and 1946.

| Food Plant | Eggs Per Female | | |
|---|---|---|---|
| | 1945 | 1946 | Average |
| Wheat | 120.6 | 113.3 | 116.9 |
| Barley | 125.0 | 47.2 | 86.1 |
| Dandelion | 94.6 | 35.7 | 65.1 |
| Brome | 80.1 | 26.1 | 53.1 |
| Oats | 84.5 | 16.0 | 50.2 |
| Flax | 65.3 | 26.0 | 45.6 |
| Sweet clover | 56.3 | 11.2 | 33.7 |
| Alfalfa | 25.7 | 0.0 | 12.8 |
| Russian thistle | 19.5 | 3.7 | 11.6 |

TABLE IV.
Biotic potential of *M. m. mexicanus* fed on various plants, 1945 and 1946.

| Food Plant | Average Percentage Survival $x$ Average Number of Eggs per Female |
|---|---|
| Wheat | 64.2 |
| Barley | 51.0 |
| Dandelion | 42.3 |
| Brome | 26.1 |
| Flax | 21.9 |
| Oats | 19.1 |
| Sweet clover | 15.5 |
| Russian thistle | 5.3 |
| Alfalfa | 2.6 |

of the plants used, followed by barley and dandelion. It indicated that alfalfa was definitely the least favourable and showed more clearly the unfavourable character of Russian thistle.

## Discussion

A consideration of all the factors studied shows that, of the plants used, wheat, barley, and dandelion were the most favourable foods for *M. m. mexicanus*. Russian thistle and alfalfa were clearly unfavourable. There are reports in the literature that alfalfa is a good food for this species, but they seem to be the result of observations on adult feeding. For instance, Pfadt (1949) stated that alfalfa was exceptionally favourable for egg production when fed to adults of *M. m. mexicanus*, and also showed that survival was high when feeding on alfalfa started in the later instars or in the adult stage. However, both Pfadt (1949) and Brett (1947) reported results comparable to those herein when alfalfa was fed to *M. m. mexicanus* from the beginning of the first instar. Shotwell (1930) and Hebard (1938) both stated that alfalfa was a preferred food of *M. m. mexicanus*, but preference was probably not a good index of nutritional value in this case.

A particularly interesting point is the apparent susceptibility to heat of grasshoppers fed on Russian thistle as indicated by the severe mortality on this food only in 1945 at temperatures about 110°F.

The fact that Russian thistle is also an unfavourable food, particularly with respect to egg production, is of significance on the western prairies, where in some areas and in some years this plant may form the major food supply.

## Summary

Various plants were used as food for *Melanoplus mexicanus mexicanus* (Sauss.), each plant being fed to one group of grasshoppers throughout three successive generations. Survival, rate of development, and number of eggs laid all varied with the different foods. Wheat, barley, and dandelion were the most favourable food plants, Russian thistle and alfalfa the least.

**Acknowledgments**

The authors wish to express their appreciation to Miss F. E. Northcott, Field Crop Insect Laboratory, Lethbridge, Alta., and Mr. Garth Thomas, formerly of the Field Crop Insect Laboratory, Brandon, Man., for assisting in rearing the grasshoppers and in tabulating the data.

**References**

Birch, L. C. 1945. The biotic potential of the small strain of *Calandra oryzae* and *Rhizopertha dominica*. *J. Anim. Ecol.* 14: 125-127.

Brett, C. H. 1947. Interrelated effects of food, temperature, and humidity on the development of the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.) (Orthoptera). *Oklahoma Agr. Expt. Sta. Tech. Bull.* T-26.

Criddle, N. 1933. Studies in the biology of North American Acrididae. Development and habits. *Proc. World's Grain Exhib. and Conf., Regina, Canada,* 2: 474-494.

Hebard, M. 1938. An ecological survey of the Orthoptera of Oklahoma. *Oklahoma Agr. Expt. Sta. Tech. Bull.* 5.

Isely, F. B. 1938. The relations of Texas Acrididae to plants and soils. *Ecol. Monographs* 8: 551-604.

Isely, F. B. 1944. Correlation between mandibular morphology and food specificity in grasshoppers. *Ann. Ent. Soc. Am.* 37: 47-67.

Isely, F. B. 1946. Differential feeding in relation to local distribution of grasshoppers. *Ecology* 27: 128-138.

Pfadt, R. E. 1949. Food plants as factors in the ecology of the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.). *Wyoming Agr. Expt. Sta. Bull.* 290.

Rubtzov, I. A. 1931. The food plants of Siberian Acrididae [in Russian]. *Bull. Plant Protection (U.S.S.R.) Ser. I. Ent. No.* 3: 13-31.

Shotwell, R. H. 1930. A study of the lesser migratory grasshopper. *U.S.D.A. Tech. Bull.* 190.

Wolcott, G. N. 1936. An animal census of two pastures and a meadow in northern New York. *Ecol. Monographs* 7: 1-90.

# Additions to the List of Ichneumonoidea from Alberta

*By* E. H. STRICKLAND
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In 1946, the writer published a list[1] of 482 species of Ichneumonoidea which included all representatives of this group contained in the University collection or which had been elsewhere recorded as occurring in Alberta. As a result of the continued generosity of Dr. H. K. Townes in naming locally collected material for us, we have, subsequently, made consistent efforts to obtain as complete a representation of the Albertan species in this group as time and opportunity have permitted. It is now possible to add about 170 species to the former list.

The majority are the result of the compiler's collecting but grateful acknowlegment is made to Dr. C. P. Alexander who, while collecting Tipulidae in the mountain resorts of this province, captured a number of Ichneumonoidea which he generously donated to this University.

With the appearance of the Synoptic Catalogue of the Hymenoptera of America[2], there is now a far more comprehensive record of the distribution of Ichneumonoidea in Canada than was generally available prior to its publication. Many species taken in Alberta are there listed as occurring, Transcontinentally or otherwise, in the Transition Zone, while few are so recorded from the Canadian Zone. It is in the latter that the majority of our captures have been made.

A number of the names which were employed in our 1946 list have been sunk into synonomy or have been transferred to new genera in the 1951 Catalogue. New records, only, are included below and they are listed under the names most recently applied to them. It is hoped that, before too long, it may be possible to record species in 109 additional genera which, at the time of writing, have been determined to genus, only.

As in the original list, each entry includes, in brackets, the initial of the determinor. As will be seen, the vast majority are credited to Townes, but to the initials so employed can now be added (M.) W. R. M. Mason, and (P.) H. D. Pratt. Where no asterisk precedes an entry this indicates that the species is not represented in the University collection though many of the determinations were made for us. Entries with no determinor's initial are taken from the literature while the few in which the word "Alta." replaces locality and date of capture are records found in the new Catalogue regarding which we have no further data. All other captures are again recorded by the "Ecological Areas" in which they have been taken. From these, it will be seen that many of these new records are from the mountainous areas of the province in which there have been few published records of Ichneumonid captures. Dr. Townes states that these are of unusual interest and that our collection contains a relatively high proportion of species which have, as yet, been undescribed.

It is a matter of regret that little progress can be made in naming the Braconidae of this province. There are well over a thousand specimens in the University collection. With the assistance of Mr. N. D. Holmes, a graduate student at this University, attempts have been made to classify this material. Species already recorded from here could, in the majority of cases, be satisfactorily redetermined but, without outside help, little of the remainder can be placed with any degree of certainty.

[1] An annotated list of the Ichneumonoidea of Alberta, *Can. Ent.* Vol. 78, pp. 36-46, 1946.
[2] Hymenoptera of America North of Mexico, Synoptic Catalog, U.S. Dept. of Agric., Monograph No. 2, 1951.

**Braconidae**

*Praon simulans Prov. (S.) 1. VIII.
Aphidius nigripes Ash. (M.) 10. V.
* obscuripes Ash. (S.) 15.
* pisivorus Sm. (S.) 10, 17. V-VI.
testaceipes Cr. (M.) 10. V.
Myiocephalus boops Wesm. Alta.
Eubadizon pleurale Cr. (M.) 10. V-VII.
Cremnops nr. washingtonensis Sch. (M.) 3. VII.
Agathis agilis Cr. (M.) 5. VIII.
laticinctus Cr. (M.) 10. VI.
Apanteles nr. banksi Vier. (M.) 10. VIII.
Microplitis melianae Vier. (M.) 10. V.
* scutellatus Mues. (W.) 10. VI.
stigmaticus Mues. (M.) 10. VI.

**Ichneumonidae**

*Pimplinae.*

*Polysphincta pallipes Hgn. (T.) 10. VII.
*Zatypota dictynae How. (T.) 10. VI.
* nigriceps Walsh. (T.) 2. VII.
* percontatoria Mull. (T.) 10, 19. VIII-IX.
*Diacritus muleibris Cr. (T.) 10. VII-VIII.
*Odontocolon aethiops Cr. (T.) 19. VII.

*Tryphoninae.*

*Netelia langtungula Thom. (T.) 10. VII-IX.
* monticola Cush. (T.) 10. VII-VIII. .
*Eclytus pleuralis Prov. (T.) 10. VIII.
*Neliopisthus semirufus Prov. (T.) 10. VI.
*Grypocentrus flavipes Prov. (T.) 10. VIII.
*Polyblastus buccatus Tow. 19. VIII.
palaemon Sch. (T.) 19. VIII.
* wahlbergi rubescens Tow. (T.) 10. VII-VIII.
flexus T. & T. (T.) 10. VI.
* fulvilineatus Hall (T.) 10. V.
articulatus Cr. (T.) 15. VII.
* bimacula T. & T. (T.) 10. VI-VIII.
galaphilus T. & T. (T.) 10, 15. VI-VIII.
* gloriosus Dav. (T.) 4. VII.
Ctenochira analis Cr. (T.) 10. VI-VIII.
debilis Tow. (T.) 19. VIII.
extricata Dav. (T.) 19. VII.
frigida Cr. (T.) 10, 19. VI-VIII.
gagates Tow. (T.) 6, 10. VI.
* rufa Ash. (T.) 10, 19. VI.
*Erromenus bedardi Prov. (T.) 19. VIII.
* dolichops Tow. (T.) 8. VI.
marginatus Prov. (T.) 10. VII-VIII.
* planus Tow. (T.) 10. VII.
proteus Tow. (T.) 10. VI.
* punctulatus Hgn. (T.) 10, 19. VI-VII.

*Monoblastus kanaicensis Hall (T.) 5. VI.
* montezuma Cam. (T.) 1, 6, 10, 17-19. VII.
*Tryphon communis foraminatus Tow. (T.) 3, 10, 19. VI-VII.
* mystax T. & T. (T.) 10, 19, 21. VI-VIII.
* rempeli T. & T. (T.) 10. VIII.
* viator Tow. (T.) 17. VI.
*Diaborus similis Dav. (T.) 10. VII.
*Smicroplectrus incompletus Wly. (T.) 10. VI.

*Gelinae.*

*Ethelurgus syrphicola Ash. (T.) 10. VI.
*Diaglyptidea lavoiei Prov. (T.) 4. VII.
Gelis atratus Ash. Alta.
*Endasys mucronatus Prov. (T.) 10. VIII.
*Eriplanus micator Grav. (T.) 10. VI-IX.
*Mesoleptus declivus Prov. (T.) 10, 19. VIII.
*Atractodes brevissimus D.T. (T.) 10, 19. VII-VIII.
* ungensis Ash. (T.) 10. VIII.
*Cubocephalus annulatus Cr. (T.) 10. VII.
* circumcinctus Prov. (T.) 10. VI-VIII.
*Aptesis tenthredinarum Roh. (T.) 10, 19. VII-VIII.
*Megaplectes monticola blakei Cr. (T.) 19. IX.
*Opidnus albicoxus Prov. (T.) 10. VI.
* tsugae Cush. (T.) 19. VIII.
*Schenkia brevicauda Ash. (T.) 10, 19. VII-IX.
*Trachysphyrus asymmetricus Pratt. (P.) 4, 6. VI-VII.
genatus Pratt. (P.) 3, 17. VII.
inornatus Pratt. (P.) 3. VI.
mimicus Pratt. (P.) 3, 19. VII.
* minimus Pratt. (P.) 3. V-VI.
* mutatus Pratt. (T.) 19. VII.
* persimilis Cr. (T.) 1, 2, 10. VII.
rugulosus Pratt. (P.) 19. VII.
ruralis Pratt. (P.) 3. VII.
symmetricus Pratt. (P.) 19. VII.
temporalis Pratt. (P.) 19. VII.
*Ischnus porrectorius F. (T.) 8, 10. VIII-IX.
* triannulatus Pr. (T.) 10. VIII-IX.
Acroricnus stylator niger Mitch. 17. VII.

*Ichneumoninae.*

*Phaeogenes arcticus Cush. (T.) 4, 10. VI.
* gaspesianus Prov. (T.) 10. VI-VII.
* hariolus Cr. (T.) 19. VIII-IX.
* hebe Cr. (T.) 10. IX.
*Diadromus helvolus Cr. (T.) 10. VII.
Dicaelotus pacificus Ash. Alta.
Apaeleticus americanus Cush. Alta.
*Platylabus clarus Cr. (T.) 10. IX.
* rubricapensis Prov. (T.) 10. VII.
* signatus Prov. (T.) 10, 17. VII-VIII.
*Pristoceros bakeri Dav. (T.) 4. VIII.
*Hypomecus quadriannulatus Grav. (T.) 10. VII.

Anisobas texensis Ash. (T.) 10. VIII.
*Neotypus nobilator Grav. (T.) 10. VI-VII.
Melanichneumon absconditus Prov. (T.) 4. VII.
*Cratichneumon popofensis Ash. (T.) 10. VII.
*Aoplus militarius Thbg. (T.) 19. VIII.
ochropis Gmel. (T.) 19. IX.
* vagus sitkensis Ash. (T.) 10. VIII.
* velox Cr. (T.) 5, 10. VI-VIII.
Exephanes subfulvus Cr. Alta.
Chasmias saucius Cr. (T.) 19. VI.
*Pseudamblyteles animosus animosus Cr. (T.) 6, 10, 15, 19. VII-VIII.
bizonatus Cr. Alta.
macilentus Cr. (T.) 10. VII.
*Amblyteles belangeri Cr. (T.) 10. VIII.
* bronteus Cr. (T.) 1, 2. VIII.
Spilichneumon taos Cr. Alta.
*Ctenichneumon electus Cr. (T.) 5. VI.
* excultus Cr. (T.) 6. VIII
Pterocormus atrox Cr. Alta.
* jucundus Br. 2. V.
* nigrovariegatus Prov. (T.) 10. VII-VIII.
volesus Cr. Alta.
zelotypus Cr. Alta.
Conocalama occidentalis lutea Hopp. Alta.

*Banchinae.*

*Glypta phloxopteridis Weid. (T.) 10. VII-IX.
*Arenetra nigrita Cr. (T.) 10. IV.
*Lissonota brunnea Cr. (T.) 10. V.
Exetastes matricus Prov. Alta.
* nervulus exploratus Dav. (T.) 10, 15. VII.
*Banchus monileatus Grav. (T.) 10. VII.

*Scolobatinae.*

*Absyrtus arealis Cush. (T.) 10. VIII.
Mesoleius aulicus Grav. 11. (possibly incorrect determination).
conformis Dav. Alta.
contractus Dav. Alta.
* nr. innoxius Cr. (T.) 5, 10. VI-IX.
* lucens Prov. (T.) 19. VIII.
* nr. striatus Dav. (T.) 10. VII-VIII.
*Synomelix obesa Dav. (T.) 10. VIII.
*Mesoleptidea decens Cr. (T.) 10, 18, 19. VII-VIII.
Hadrodactylus elongatus Cr. Alta.

*Plectiscinae.*

*Proclitus royi Prov. (T.) 10. VI-IX.
*Plectiscidea nasoni Dav. (T.) 10. IX.

*Diplazoninae.*

*Diplazon scutellaris Cr. (T.) 2. VII.
*Zootrephus bizonarius Grav. (T.) 10. V.
Syrphoctonus albopictus Dav. Alta.
*Enizemum petiolatum Say (T.) 4, 10. VI-VII.
ornatum Grav. Alta.

*Metopiinae.*

*Hypsicera femoralis Four. (S.) 10. IV.
Exochus flavifrontalis Dav. Alta.
* pallipes Cr. (T.) 10. VII.
* xanthopsis Ash. (T.) 10. VII.

*Ophioninae.*

*Pyracmon macrocephalum Prov. (T.) 10. VII.
*Campoplex atridens Tow. (T.) 15. VIII.
* fusiformis Prov. (T.) 10. VII-VIII.
* hyalinus Prov. (T.) 10. VII.
* infumatus Prov. (T.) 3. VII.
* tortricidis Cush. (T.) 10, 19. VIII.
Casinaria forcipata Wly. (W.) 17. VIII.
* scabriformis Vier. (T.) 1. VIII.
*Campoletis distinctus Pr. (T.) 10. VI.
lipomerus Vier. Alta.
* perdistinctus Vier. (T.) 19. IX.
* tibialis Vier. (T.) 17. VII.
Campoplegidea grahami Wly. (W.) 19. VI.
* insolita Wly. (T.) 10. VII.
*Horogenes eureka Ash. (T.) 10. VII-VIII.
* obliterata Cr. (T.) 19. IX.
*Olesicampe kincaidi Dav. (T.) 19. VII.
* typica Vier. (T.) 10. VII.
*Cremastus chilonis Cush. (T.) 10. VII.
*Leptopygus borealis Prov. (T.) 4, 10. VII.
Barylypa elongata Dav. Alta.
Gravenhorstia curtus Nort. Alta.

*Mesochorinae.*

*Mesochorus sylvarum Curt. (T.) 10. VII-VIII.

**Gasteruptionidae**

Aulacostethus resutorivorus West. (T.) 10, 19, 20. VII.
*Gasteruption assectator L. (T.) 7, 8, 10, 15, 19. VI-VIII.
*Rhydinofoenus barnstoni West. (T.) 2, 7, 8, 10, 15. VI-VII.
* perplexus Cr. (T.) 2, 17., VI.
septentrionalis Sch. (T.) 18. VII.

# *Chlamisus* sp. (Coleoptera: Chrysomelidae), a New Pest of Strawberries

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In July, 1949, a single specimen of a casebearing coleopterous larva was found feeding on a strawberry leaf in a plantation at the southeastern end of Grand Lake, Queen's County, N.B. During June and July, 1950, about a dozen larvae were found throughout this area, and a greater number in plantations on both sides of Washademoak Lake, which is southeast and roughly parallel to Grand Lake and about ten miles distant. During 1951 the species was again collected in these areas, and was found in large numbers about 15 miles southeast of Washademoak Lake in the Belleisle watershed. Here the infestation was so great that in one instance 565 larvae were collected with a sweeping net on 100 feet of strawberry row, or an average of five larvae per plant.

The damage caused by the insect feeding on the foliage and fruit was so heavy that some plantations were ploughed under by the owners. Although extensive searches were made in the infested areas, and particularly in and about heavily attacked plantations, other host plants were not found. On a few properties where Premier strawberries were grown in addition to the standard Senator Dunlap variety, the former was noticeably less heavily attacked than the latter. Infestations appeared to be fairly evenly distributed within the plantations, no gregarious tendencies being observed in the feeding larvae. However, the pupae were typically found in clusters on the crowns of the plants.

From a series of field-collected material Mr. W. J. Brown, Division of Entomology, Ottawa, determined the insect to be an undescribed species of *Chlamisus* Raf. (=*Chlamys* Knoch=*Arthrochlamys* Ihering).

The habits of the species are similar to those reported for *Chlamisus plicata* (Fab.) (Popenoe and Marlatt, 1889; Briggs, 1905).

The larva is enclosed in a deep-brown or blackish dome-shaped case composed of excreta. In the last larval instar the case is approximately 5.5 mm. high and 3.2 mm. wide. The opening at the lower end is somewhat constricted, permitting only the thoracic legs and mouth parts to extrude. The larva is strongly curved to conform to the shape of the inside of the case and fits it somewhat loosely. The caudal end is somewhat enlarged and is in position near the top of the case. Colour varies from pink to rose.

The adult is about 3.5 mm. in length, dark coppery in colour, roughly sculptured, and almost cubical in form.

Late in May adults appeared in cages set out for strawberry weevil emergence. Larvae were found from about the middle of June to the end of July. During this time they fed voraciously on the strawberry plants. Although attacking all aerial parts of the plant including the fruit, the larvae showed a strong preference for the leaves, sometimes almost completely devouring them, leaving only the main veins.

Pupation occurs within the case. Cases containing pupae were found typically on the crowns of the plants, often in clusters of as many as four cases attached to one another. New adults appeared about the middle of August and remained active in the plantations until late September, feeding voraciously on the leaves. The species no doubt overwinters in the adult stage.

No parasites emerged from larvae collected in the plantations and reared in the insectary during 1951, although parasitism is very high in other species of the genus (Brown, 1943).

Although the genus *Chlamisus* has not been considered of great economic importance, the following fruits have been reported as hosts: blackberry (Briggs, 1905), blueberry (Phipps, 1930), and huckleberry (Smith, 1910, p. 340).

**References**

Briggs, E. M. 1905. The life history of case bearers: I. *Chlamys plicata*. *Cold Spring Harbor Monogr.* 4: 3-12.

Brown, W. J. 1943. The Canadian species of *Exema* and *Arthrochlamys* (Coleoptera, Chrysomelidae). *Canadian Ent.* 75: 120-131.

Phipps, C. R. Blueberry and huckleberry insects. *Maine Agr. Expt. Sta. Bull.* 356. 1930.

Popenoe, A. M., and C. L. Marlatt. 1889. The sycamore leaf beetle, *Chlamys plicata* (Fab.). *In* First Ann. Rept. Kansas Expt. Sta., 1888, pp. 203-205.

Smith, J. B. 1910. (Insects of New Jersey) *Ann. Rept. New Jersey State Mus.*, 1909.

## Book Review

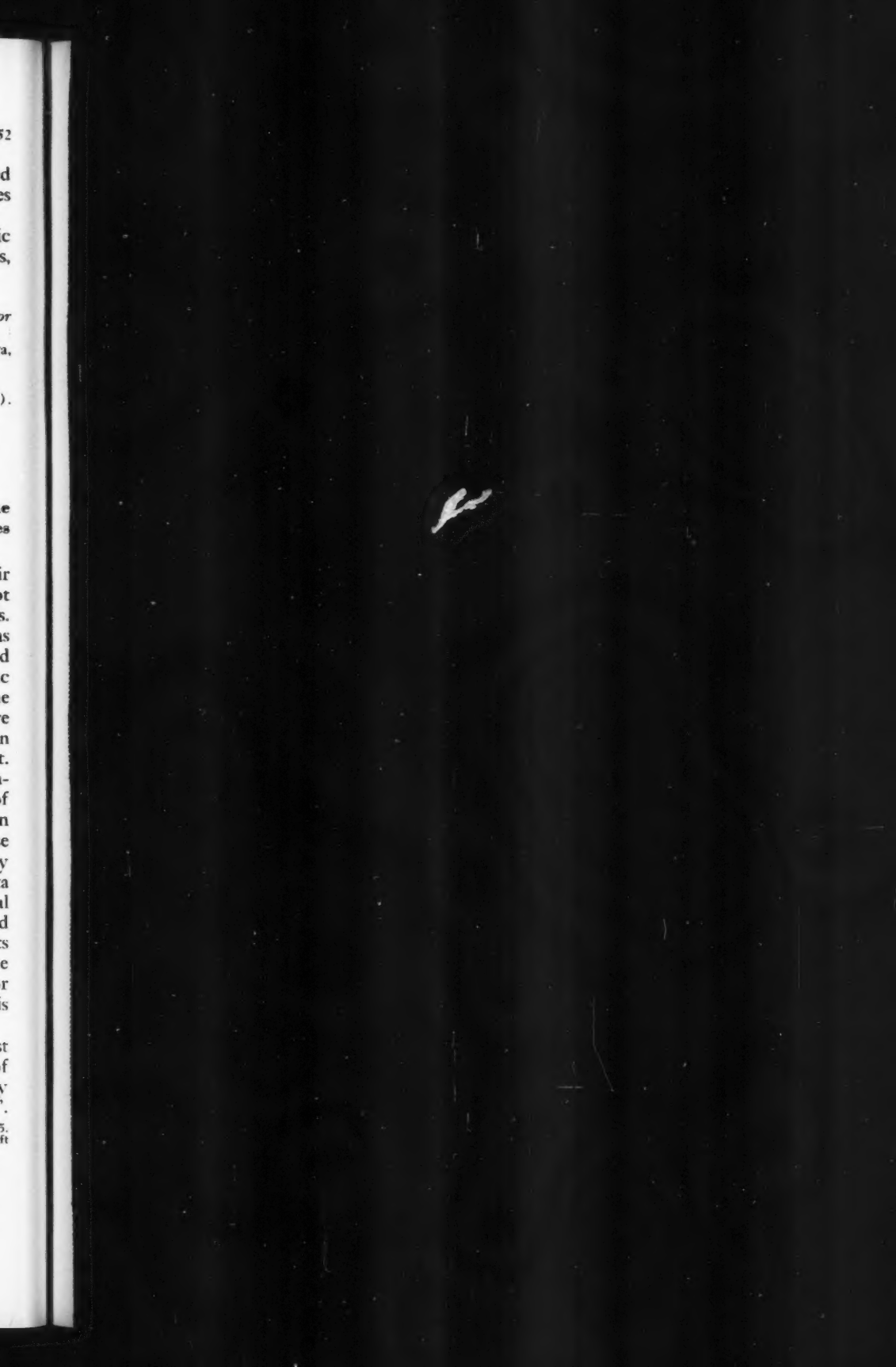
**An Introduction to Acarology, by Edward W. Baker and G. W. Wharton, The Macmillan Co. of New York and Toronto, 465 + xiii pages, 375 figures and 6 plates, 1952.**

At long last two of the foremost American acarologists have, by their combined efforts, placed zoologists of the English speaking world in their debt by providing them with a readily available introduction to the study of mites. In essence this book, which should be useful to the general zoologist as well as to the advanced student, is an illustrated catalogue of the families, genera and genotypes of the order Acari. In so far as it follows quite closely the taxonomic categories of Count Herman von Vitzthum's great German work* on the same subject, it should serve to effect a greater degree of unanimity in nomenclature between European and American workers. Any person who has studied or even prospected in this field will appreciate the sentiment expressed in the last statement.

By way of criticism, this reviewer would like in the first instance to congratulate the publishers on the quality of the printing and the general format of the volume, and the authors on the type of line drawings which they have chosen to illustrate the main species discussed. My only regret is that more of these excellent figures were not included, especially of the more obscure and less readily available species. It is somewhat regrettable that in discussing the Mesostigmata more use could not have been made of Trägårdh's elaborate morphological studies, but this is understandable as the Swedish author's work does not lend itself readily to summation. There are a few places in the text where specialists in particular groups would have chosen different names but as the authors have in the main followed the accepted systems of classification these are minor subjective points which do not in the least detract from the overall value of this well written, free from error book.

In conclusion we can for once agree with the publishers' screed on the dust jacket which runs as follows: "The book will be a valuable text for students of zoology and entomology, as well as an important reference for all those actively engaged in pest control, public health, and medical or veterinary entomology".

*Vitzthum, Herman von. 1940-43. Acarina in Bronn's Klassen und Ordnungen des Tierreichs. 5. Band Arthropoda, IV. Abteilung: Arachnoidea, 5 Buch Acarina. Leipzig Akademische Verlagsgesellschaft Becker and Erler. Kom-Ges.

H. H. J. Nesbitt.

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